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(54) Abstract Title
A common rail fuel injection system with an overflow valve for an i.c. engine

(57) A fuel injection supply system for a compression ignition internal combustion engine using heavy fuel oil comprising a low pressure pump 4, a heater 6, a high pressure pump 8 with a suction chamber 12 and by-pass 16, a fuel accumulator line 15 which feeds all the injector valves 18 and an overflow valve 21. The overflow valve 21 may be opened when the engine is not running allowing fuel to circulate through the system so that it can still be heated and thus preventing the system from becoming blocked. The overflow 21 valve may be hydraulically or electromagnetically operated.

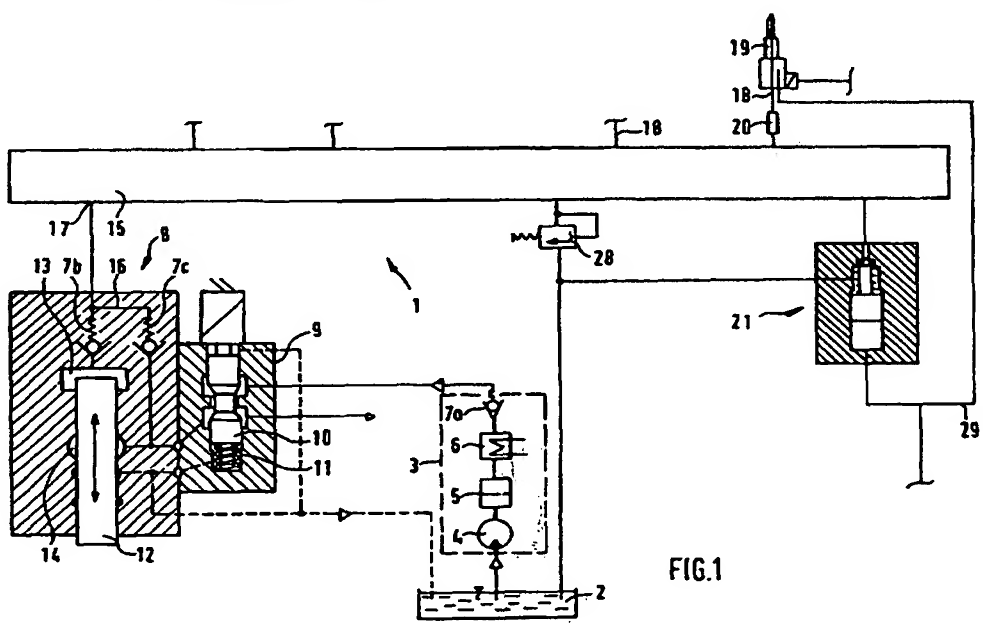

FIG.1

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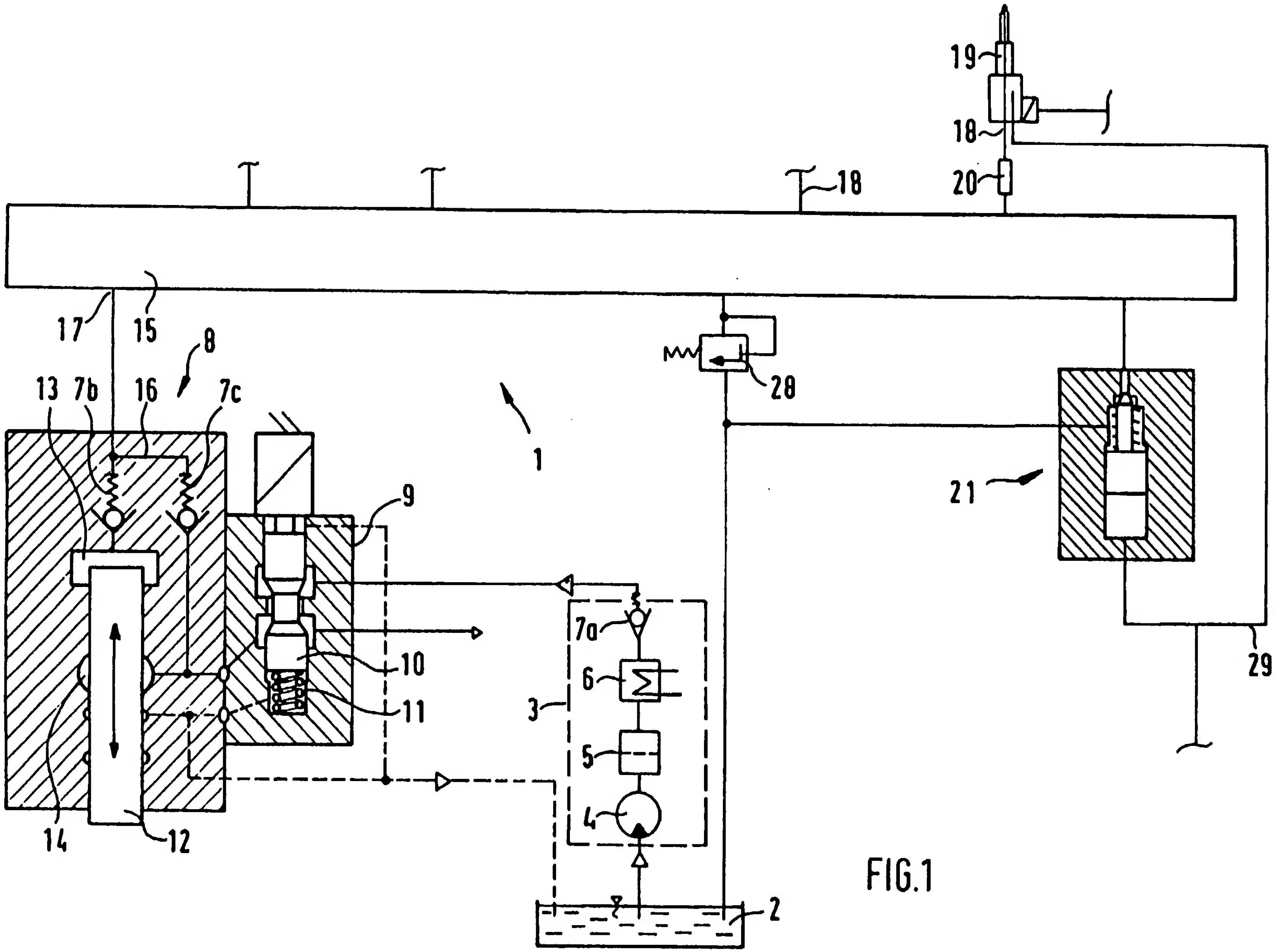

FIG.1

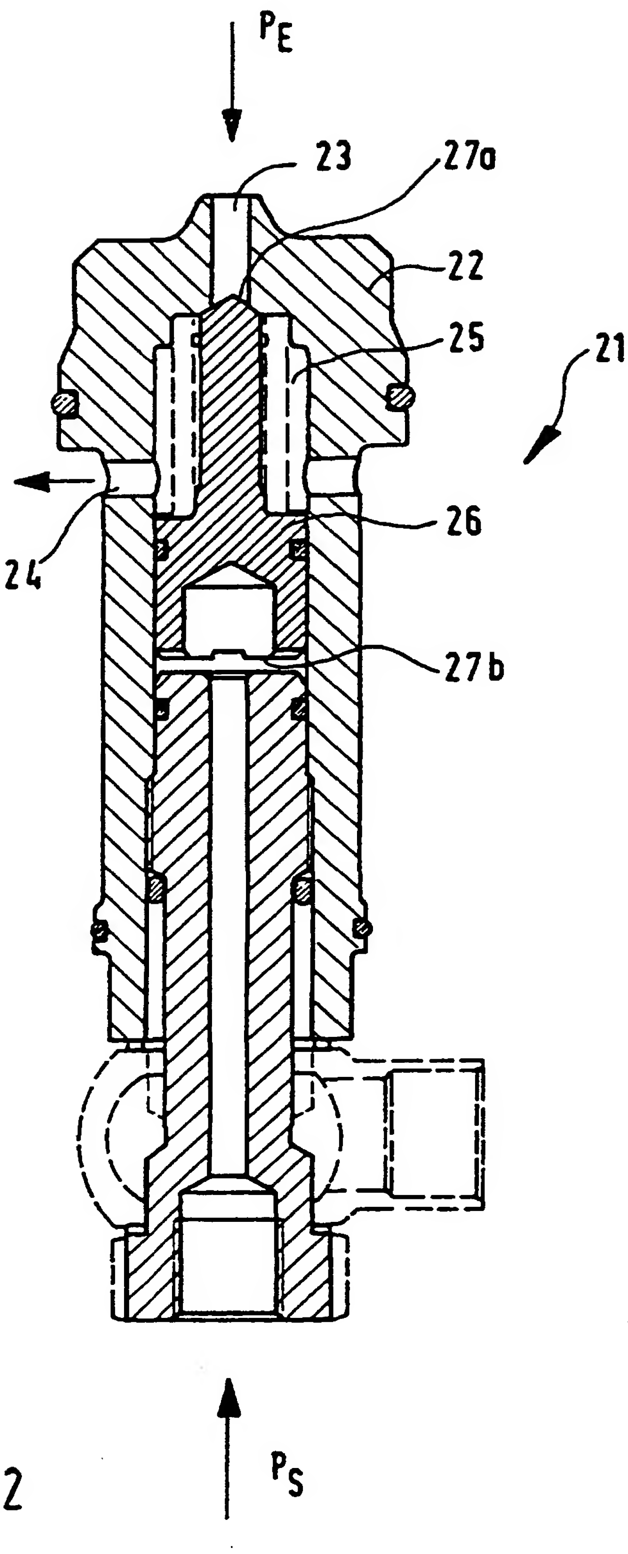

FIG.2

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Pressure-Accumulator Injection Device

The invention relates to a fuel injection device for heavy-oil-driven diesel combustion engines, comprising a high-pressure pump feeding fuel from a suction chamber into a pressure-accumulator line, to which fuel injectors are connected, wherein heavy oil is conveyed from a fuel tank to the high-pressure pump via a fuel processing installation. An injection device of this type is disclosed in EP 666 416 A1.

Heavy-oil-driven combustion engines are distinguished from diesel-driven combustion engines by lower running costs, since heavy oil is considerably cheaper than diesel. Heavy-oil-driven combustion engines have thus established themselves as propulsion systems for ships since the fuel accounts for almost 40% of the overall running costs of a propulsion system. Owing to the problematic corrosive properties and viscosity characteristics of heavy oil, particular requirements have to be placed on the engine and the injection device. Above all, frictionless starting, stopping and running must be ensured with low-grade heavy oils for the entire load range of the combustion engine. In particular, the tendency of the heavy oil towards paraffin separation must be taken into consideration when the combustion engine is stopped and the temperature in the injection device consequently drops.

In order to be able to re-start the engine without difficulty at low temperatures even after a relatively long rest period, it is known to switch over to diesel running before stopping the engine so that, once the engine has stopped, there is only diesel still in the lines and components of the fuel injection device, which is less problematic with respect to viscosity and

paraffin separation. It is also known from literature (*Schiff und Hafen*, no. 3/1987, pages 30 to 34) to heat up heavy oil and injectors by means of a separate thermal fluid in order to prevent paraffin formation. However, both solutions require the use of additional apparatus.

On the basis hereof, the object of the invention is to provide a fuel injection device of the type in question, by means of which it is possible to start up and run a diesel combustion engine in a trouble-free manner using heavy oil with as little structural expenditure as possible.

According to the invention, the object is achieved by the fuel processing installation being provided with a heater for preheating the heavy oil and by the pressure-accumulator line having an overflow valve opening while the engine is at a standstill for the circulation of heated heavy oil through the high-pressure pump and pressure-accumulator line.

The invention has the advantage that, by using preheated heavy oil, a separate heating means is unnecessary, thereby avoiding expenditure for separate circuits. The heavy oil is heated up in a fuel processing installation, for example via a heat exchanger which heats the heavy oil to a temperature at which paraffin separation is avoided and there is adequate viscosity of the heavy oil. Therefore, the heavy oil can be fed to the injection-side high-pressure pump or the suction chamber communicating with the pump by means of a low-pressure feed pump at comparatively low pressure. The engine coolant can be used to heat up the heavy oil so that additional heating energy does not have to be applied for preheating the heavy oil. By means of an overflow valve installed in the pressure-accumulator line, the circulation of heated heavy oil in the injection device can be maintained so that there is heated and consequently flowable heavy oil in the components of the injection device until the combustion engine is started up. Only by using

a flowable heavy oil can it be ensured that the high-pressure pump and the fuel injectors operate reliably and within the bounds of their optimum operating limits. At the same time, the circulation provides the possibility of ventilating and simultaneously filling the high-pressure pump, suction chamber and pressure-accumulator line should these components be empty after the engine has stopped.

In accordance with the features of claims 2 and 3, the overflow valve is usually arranged at the end of the pressure-accumulator line so that the pumps or injector connections are heated and cannot become blocked by paraffin formation.

In order to prevent malfunctioning due to excessive discharge of heavy oil in the event of a defective injector, quantity-limiting valves are interposed between the pressure-accumulator line and the injectors.

In a further development of the injection device, the overflow valve is formed as a pressure relief valve in accordance with the features of claim 5 so that the accumulator line is relieved of pressure if an operating pressure is exceeded. By combining the overflow valve with the function of a pressure relief valve, further structural expenditure can be saved and the reliability of the entire system can be increased by the omission of an additional valve.

For maximum economy, it is necessary in the meantime to optimise the running properties of combustion engines through connection to a usually electronic engine control unit. By incorporating the overflow valve into the engine control unit, the overflow valve can be automatically operated at the correct moment in accordance with the operating state, e.g. start-up, continuous running, engine stop, standstill and ventilation.

In a further development of the fuel injection device, in accordance with the features of claims 7 to 11, the overflow valve is operated by a hydraulic control fluid. Apart from the advantages of hydraulically operated valves, such as reliability and high displacement forces while being of compact construction, the control fluid pressure takes on a safety function, namely if the necessary control fluid pressure is not applied to the overflow valve, the pressure-accumulator line is not shut off and the combustion engine is thus prevented from starting up. This is of particular importance if, during simultaneous operation of the injectors by the control fluid, the injectors are not yet capable of operation owing to the control pressure being too low. This prevents the injectors from being acted upon by high pressure before the control pressure necessary for their operation has been reached. Owing to a hydraulic conversion, which is brought about by adapting the pressure surfaces acted upon by the control fluid or fuel pressure, the necessary control fluid pressure can be considerably less than the fuel pressure in the pressure-accumulator line. This results in further simplification of the control hydraulics.

As an alternative to hydraulic operation of the overflow valve, electromagnetic operation is proposed, wherein a safety function is also assignable to the overflow valve in that the latter opens in the absence of magnetic flow. In the event of disrupted flow through the likewise electromagnetically operated injectors, this prevents the combustion engine from starting while the pressure-accumulator line remains pressureless. As soon as the overflow valve and with it the injectors are under pressure, the pressure-accumulator line can be closed to start the engine.

Since passage through the high-pressure pump from the suction chamber to the pressure-accumulator line via the pump operating chamber is not always possible, depending on the construction, the high-pressure pump has a

suction-chamber overflow line arranged in parallel and connecting the suction chamber of the high-pressure pump to the pressure-accumulator line, bypassing the pump operating chamber. In addition to the direct action of the heated heavy oil on the pressure-accumulator line, the suction chamber is also supplied with the circulating heavy oil, thus ensuring adequate heating of the entire pump by means of the suction chamber extending in a substantially annular manner in the high-pressure pump. A non-return valve arranged in the pressure-accumulator line ensures that the fuel under high pressure cannot flow away in the suction-chamber overflow line during the start-up and running of the engine.

A fuel quantity regulator is arranged between the high-pressure pump and the fuel processing installation for metering the quantity of fuel both during the operation of the combustion engine and during the heating-up operation before start-up. By arranging the fuel quantity regulator in the circulation circuit, the latter is also heated up by the heavy oil. Further advantageous embodiments of the invention are disclosed by the features of claims 14 and 18.

A preferred embodiment of the invention will be described in the following with reference to the accompanying drawings, wherein:

Fig. 1 shows a diagram of a fuel injection device with a fuel processing installation, and

Fig. 2 shows a longitudinal section through an overflow valve of the fuel injection device.

The diagram according to Fig. 1 shows a fuel injection device 1 for a combustion engine operating on the diesel principle and not shown in further

detail. The combustion engine is designed to run on heavy oil, which is supplied from a fuel tank 2 to the injection device 1 via a fuel processing installation 3. The fuel processing installation 3 comprises a low-pressure feed pump 4, a fuel filter 5, a heater 6 formed as a heat exchanger and a non-return valve 7. With these components 4, 5, 6 and 7, the fuel processing installation 3 supplies heavy oil at a pressure of at least 3 bar and a temperature of approximately 160° to the high-pressure pump 8 of the injection device 1. The heavy oil supplied to the high-pressure pump 8 is metered by an electromagnetically operated metering valve 9, the closing member 10 of which is acted upon by a spring 11 operating in the closed position. The metered quantity of fuel is then supplied to the suction chamber 12 of the high-pressure pump 8 constructed as a piston pump. From the suction chamber 14 surrounding the feed piston 12 or pump operating chamber 13 in an annular manner, heavy oil flows into the pump operating chamber 13 to then be fed into a pressure-accumulator line 15 at a high pressure of up to 2000 bar during the operation of the combustion engine. In order to avoid a drop in pressure in the pressure-accumulator line 15 during the suction stroke of the high-pressure pump 8, a non-return valve 7b is provided at the outlet of the pump operating chamber 13. To be able to ensure circulation of the heavy oil before the start-up of the engine in any rest position of the piston 12, a suction-chamber overflow line 16 is arranged in parallel with the high-pressure pump 8. This overflow line 16 connects the suction chamber 14 to the pressure-accumulator line 15, bypassing the pump operating chamber 13. A further non-return valve 7c is interposed in the overflow line 16 in order to prevent pressure loss or backflow from the pressure-accumulator line 15. In contrast to the operating chamber non-return valve 7b, the non-return valve 7c of the overflow line 16 opens under very much lower fuel pressure in the overflow line so that circulation of heated heavy oil is made possible.

The pressure-accumulator line 15, connected downstream of the high-pressure pump 8 and known as a common rail, is distinguished by an internal pressure accumulator having a considerably greater storage volume than the volume of the remaining lines under high pressure. Downstream of the pump connection 17, the lines 18 to the injectors 19 branch off at substantially uniform intervals, the injectors 19 injecting the heavy oil into the combustion chambers (not shown in further detail) of the combustion engine. A quantity-limiting valve 20 is arranged upstream of each of the injectors 19 and, in the event of a leak downstream or a defective injector 19, prevents unintentional discharge of fuel in order to keep the remaining, still functioning injectors 19 operational.

An overflow valve 21 is arranged at the end of the pressure-accumulator line 15 opposite the pump connection 17 and opens the pressure-accumulator line 15 before start-up in order to heat up the injection device 1 and fill the pressure-accumulator line 15. At the outlet end, the heavy oil flowing from the pressure-accumulator line 15 is fed back to the fuel tank 2. The lines 18 to the injectors are enclosed between the pump connection 17 and the overflow valve 21 so that the entire length of the pressure-accumulator line 15 is filled and heated during the circulation of preheated heavy oil.

The overflow valve 21, shown in detail in Fig. 2, has a valve housing 22 with a fuel inlet at the pressure-accumulator end and a fuel outlet 24 at the tank end. The connection between the fuel inlet 23 and the fuel outlet 24 is opened and closed by means of a closing member 26 movably mounted in a valve chamber 25. By means of an end sealing surface 27, the closing member 26 closes the fuel inlet 23 as long as the combustion engine is in operation. Consequently, the full pressure can build up in the pressure-accumulator line 15. The closing member 26 is held in the closed position by a second pressure surface 27b acted upon by the control fluid pressure, the

ratio of the effective pressure surfaces 27a, b being substantially greater than 1, and thus the necessary control fluid pressure for closing the closing member 26 can be considerably lower than the accumulator pressure, which is up to 2000 bar. In addition, the closing member 26 is acted upon in the opening direction by a spring 11b so that the overflow valve 21 always remains open when the injection device is pressureless.

To limit the excess pressure in the pressure-accumulator line 15, a pressure relief valve 28 is connected thereto and opens a connection from the pressure-accumulator line 15 to the fuel tank 2 when a specified limit pressure is exceeded. If the pressure surfaces 27a and 27b of the overflow valve 21 are adapted accordingly, this safety function can be incorporated into the overflow valve 21 so that a separate valve is unnecessary.

Claims

1. A fuel injection device for heavy-oil-driven diesel combustion engines, comprising a high-pressure pump for feeding fuel from a suction chamber to a pressure-accumulator line, to which fuel injectors are connected, a fuel processing installation for supplying heavy oil from a fuel tank to the high-pressure pump, wherein the fuel processing installation is provided with a heater for preheating the heavy oil, and the pressure-accumulator line has an overflow valve opening while the engine is at a standstill for the circulation of heated heavy oil through the high-pressure pump and pressure-accumulator line.

2. A fuel injection device according to claim 1, wherein the overflow valve is remote from a connection of the pressure-accumulator line to the high-pressure pump.

3. A fuel injection device according to either one of the preceding claims, wherein lines to the injectors branch off from the pressure-accumulator line between a connection of the pressure-accumulator line to the high-pressure pump and the overflow valve.

4. A fuel injection device according to any one of the preceding claims, wherein a respective quantity-limiting valve is interposed between the pressure-accumulator line and each injector connected thereto.

5. A fuel injection device according to any one of the preceding claims, wherein the overflow valve is formed as a pressure relief valve opening the pressure-accumulator line when an operating pressure therein is exceeded.

6. A fuel injection device according to any one of the preceding claims, wherein the overflow valve is connected to an engine control unit controlling the operation of the overflow valve.

7. A fuel injection device according to any one of the preceding claims, wherein the overflow valve is hydraulically operated.

8. A fuel injection device according to any one of the preceding claims, wherein the overflow valve has a hydraulically operated closing member acted upon in the closed position when a control fluid pressure is applied.

9. A fuel injection device according to claim 8, wherein the overflow valve has a valve spring operating the closing member in the opening direction so that the closing member opens when the pressure in the control fluid drops.

10. A fuel injection device according to claim 8 or 9, wherein the closing member has a closing surface acted upon by the fuel pressure of the fuel-accumulator line, and a pressure surface acted upon by the control fluid, the closing surface being smaller than the pressure surface so that, in accordance with the spring constant of the valve spring, the control fluid pressure necessary for operating the closing member is less than the fuel pressure.

11. A fuel injection device according to any one of claims 8 to 10, wherein the injectors are operated by the control fluid.

12. A fuel injection device according to any one of claims 1 to 6, wherein the overflow valve and the injectors are electromagnetically operated.

13. A fuel injection device according to claim 12, wherein the overflow valve opens in the absence of magnetic flow.

14. A fuel injection device according to any one of the preceding claims, wherein the overflow valve has a line connection to the fuel tank at the outlet end thereof.

15. A fuel injection device according to any one of the preceding claims, wherein the injection device has a suction-chamber overflow line arranged in parallel with the high-pressure pump and, for the purpose of filling the pressure-accumulator line, connects the suction chamber to the pressure-accumulator line via a non-return valve.

16. A fuel injection device according to any one of the preceding claims, wherein a valve for metering the quantity of fuel is arranged upstream of the suction chamber, the fuel quantity controlling the flow rate during overflow running.

17. A fuel injection device according to claim 16, wherein the flow rate during overflow running is a function of the fuel viscosity and/or temperature.

18. A fuel injection device according to claim 16 or 17, wherein the metering valve is connected to an engine control unit controlling the operation of the metering valve.

19. A fuel injection device substantially as herein described with reference to the accompanying drawings.

The Patent Office

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Application No: GB 9722860.5
Claims searched: 1-19

Examiner: David Glover
Date of search: 23 February 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): F1B

Int Cl (Ed.6): F02M 37/00, 37/04, 37/06, 37/08, 37/18

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2202903 A	(Daimler-Benz AG)	
A	GB 2045347 A	(Institut Für Moterenbau)	
A	US 5277156	(Osake *et al*)	
A	US 5109822	(Martin)	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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